This invention relates generally to means for inspecting workpieces and more particularly to means for inspecting workpieces and materials through the use of high frequency energy waves to determine material thickness, the presence of material defects, and other material characteristics.

Ultrasonic, supersonic and high frequency inspection devices have been found highly adaptable for inspecting workpieces and materials in that they do not damage or require the destruction of the object under inspection. Several methods of ultrasonic and high frequency material inspection have been proposed in the past. These methods include means for transmitting a single shock wave or pulse of energy into a workpiece and measuring the interval of time required for the wave to travel through the object. This is a single step operation requiring the initiation of another pulse for each inspection.

Another method requires transmitting a continuous wave of energy through an object and measuring or detecting the variation in the amount of energy received. This method is dependent upon the composition of the material through which the wave is transmitted as well as the consistency of the material. Still another method includes transmitting energy pulses through a workpiece at prescribed spaced intervals and in measuring or comparing the intervals at which such pulses are received. Here again the composition of the material will vary the inspection results obtained. A still further method of inspection includes pulsing ultrasonic or high frequency shock waves through a workpiece at set intervals and detecting the rate of change of energy received as an indication of the presence of material defects or flaws. This latter method is adaptable for flaw detection only.

It is now proposed to provide an improved means of using high frequency shock wave energy for the inspection of workpieces and materials thereof which will allow continuous inspection independently of the composition of the material and of the actual energy loss in passing a wave or pulse through the material under inspection. It is proposed to provide a means for transmitting pulses or waves at high frequency into a workpiece and having each pulse as it emerges from the workpiece initiate or trigger the succeeding pulse. Since the time required for a shock wave or pulse to travel through a workpiece is a function of the velocity of sound through the material and of the length of the sonic path, the rate of pulse repetition, each pulse being triggered by the next preceding pulse, is directly proportional to the velocity of sound through the workpiece material and inversely proportional to the length of the sonic path through the workpiece. It is therefore proposed to calibrate an instrument adapted to indicate the rate of pulse repetition in units of sonic path length for measuring the thickness of the material under inspection. The proposed device is also adapted for flaw detection since any flaws or defects within the material under inspection will vary the rate of pulse repetition and provide an indication of such defect.
to a video receiver 30, multivibrator 32, delay circuit 34, another multivibrator 36 and a power pulse amplifier 38, each connected to the other in the order given. With the circuit switch 41 in the position shown, a shock wave emerging from the work member 26 causes the transducer 24 to generate an electrical pulse. The pulse is transmitted through the switch 41 to the video receiver 30. The video receiver 30 is preferably of the type shown and described in the textbook "Microwave Receivers" by Van Voorhis, McGraw-Hill, 1948, page 534 and Figure 19-22. The video receiver 30 amplifies the electrical pulse and triggers the one-shot multivibrator 32. Both of the multivibrators 32 and 36 are essentially similar to the triggered pulse generator 10 mentioned previously. The wave form or shape of the pulse obtained from the multivibrator 32 is a steep wave front type which permits an accurate delaying of the signal by the delay circuit 34. The delay circuit 34 is such as is shown and described in the textbook "Electronic Time Measurement" by Chance, Hulsizer, MacNichol and Williams, McGraw-Hill, 1949, page 131, Figure 5-14.

Following the delay imparted to the pulse signal in the delay circuit 34, the pulse triggers the multivibrator 36 which sends out a signal to the power pulse amplifier 38. Another variable type of power pulse amplifier is shown and described in the McGraw-Hill textbook "Vacuum Tube Amplifiers" by Valley and Wallman, 1948, page 144, Figure 3-29. The transducer 24, upon receipt of the signal from the power pulse amplifier 38, generates a mechanical impulse which sends another shock wave into the work member 26 where it traverses the work member, reflects off the opposite side thereof, and returns to the transducer to begin again the recurrent cycle.

The operating electrical pulse generated by the multivibrator 32 passes through delay circuit 34, triggers a second multivibrator 36 whose electrical output pulse furth passes through a meter 46, amplifier 38, and is then applied to the transducer 24 where it is converted into a mechanical pulse which is applied to the work member. The reflection of the mechanical wave from the opposite side of the work member sets up vibrations in the transducer and creates an electrical pulse. This last named pulse is fed back through line 28 to apply a trigger voltage to the video receiver to initiate the next pulse to be transmitted into the part. Means are provided to de-activate the video receiver after it has triggered one pulse unit until that pulse has traversed the path just outlined and has been reflected in the part to the receiving transducer at which time the video receiver is reactivated so that this reflected pulse may trigger the next pulse from the multivibrator 32. In order to deactvate the video receiver 30 as mentioned herein, a delay circuit is provided between the output of the multivibrator 32 and the video receiver 30. As mentioned previously, the delay circuit 34 is connected to the delay circuit 34 and the multivibrator 36 and power pulse amplifier 38. The driving signal from the one-shot multivibrator 32, therefore, cuts off the video receiver 30. It is necessary to keep this video receiver cut off until the driving pulse has been applied to the transducer 24 and to then reactivate it so that it is ready for the reflected signal from the part applied to transducer 24. In this case the circuit gate 49 is switched back by a signal from the multivibrator 36 through a delay circuit 43 in the connection 44 between the output of the multivibrator 36 and the circuit gate 49. The arrival of such signal reactivates the video receiver. The time delay introduced by delay circuit 42 is sufficient to prevent reactivation of the video receiver until the driving pulse has been applied to the transducer 24.

The output of the multivibrator 36 will be a constant amplitude rectangular pulse at a repetition rate determined by the length of the sonic path through the work member 26. A meter 46 is mounted between the multivibrator 36 and the power pulse amplifier 38 to read the average output of the multivibrator 36 as an indication of the pulse repetition rate and is calibrated in units of sonic path length so that the reading obtained may be correlated to obtain thickness measurements for any given material in accordance with the known velocity of sound through such material.

Where separate input and pick-up transducers may be used, a separate circuit 48 with a pick-up transducer 50 may be adapted to the circuitry 26 of Figure 3 and the switch 41 adapted to connect the transducer therein. With this latter arrangement the separate pick-up transducerpick-up\(^\text{1}\) in Fig. 11, is capable of controlling the video receiver 30 should be adjusted to the minimum setting at which oscillations are sustained to reduce the chance of lower amplitude shock waves in the work member 26, which may follow longer or multiple paths, being adequate to trigger the system at random rates. The delay time inherent in the delay circuit 34 should also be sufficiently large to assure complete dying out of all multiple reflections before a new cycle is initiated. However, it is advisable to keep the ratio of work member delay time to multivibrator delay time as large as possible to obtain the highest accuracy of measurement.

We claim:

1. A device for inspecting work members which includes a transducer adapted to be disposed against the surface of a work member for transmitting a mechanical impulse into said work member and for receiving an impulse reflected back thereto, said transducer converting said reflected impulse into an electrical pulse, a multivibrator connected to said transducer for receiving said electrical pulses and adapted to be triggered by said electrical pulse for initiating a single steep wave front pulse, a second multivibrator producing said delay wave pulse and being adapted to be triggered thereby to initiate a single wave signal, said transducer being connected to said second multivibrator for receiving said wave signal and for converting said signal into a mechanical impulse and for applying said impulse into said work member, means connected between the outlet side of said second multivibrator and the inlet side of said first-mentioned multivibrator for preventing said first-mentioned multivibrator from receiving said wave signal, and means connected between said second multivibrator and said transducer for measuring the repetitious rate of wave initiation by said second multivibrator as an indication of the sonic path length through said work member and the presence of defects and flaws therein.

2. A device for inspecting work members which includes a transducer adapted to be disposed against the surface of a work member for transmitting a mechanical impulse into said work member and for receiving an impulse reflected back thereto, said transducer converting said reflected impulse into an electrical pulse, means connected to said transducer for receiving and amplifying said electrical pulse, a one-shot multivibrator connected to said last-mentioned means for receiving the amplified electrical pulse emitted therefrom and adapted
to be triggered by said amplified electrical pulse to initiate a single steep wave front pulse, a second one-shot multivibrator producing square wave pulses connected to said first-mentioned multivibrator, means connected between said multivibrators for momentarily delaying the transmission of said wave pulse theretobetween to provide time to deenergize said means for receiving and amplifying said electrical pulse, said second multivibrator receiving said delayed wave pulse and being triggered thereby to initiate a single wave signal, means connected to said second multivibrator for receiving and amplifying said wave signal and connected to said transducer for transmitting the amplified wave signal thereto, said transducer converting said amplified wave signal into a mechanical impulse and applying said impulse to said work member, means connected between the outlet side of said second multivibrator and the inlet side of said first-mentioned multivibrator for preventing the triggering of said first-mentioned multivibrator upon receipt of a wave signal from said second multivibrator, and means connected between said second multivibrator and said transducer for measuring the repetitions rate of wave initiation by said second multivibrator as an indication of the length of the sonic path through said work member and the presence of defects or flaws therein.

3. A device for inspecting work members, said device including a transducer adapted to be disposed against the surface of a work member for receiving a mechanical impulse therefrom and for converting said impulse into an electrical pulse, a video receiver connected to said transducer for receiving and amplifying the electrical pulse received from said transducer, a one-shot multivibrator connected to said video receiver for receiving the amplified electrical pulse emitted from said receiver and adapted to be triggered thereby to initiate a single steep wave front pulse, a delay circuit connected to said multivibrator for receiving said wave pulse and for delaying the transmission thereof for a given interval of time to provide time to deenergize the video receiver, a second one-shot multivibrator producing square wave pulses connected to said delay circuit for receiving said wave pulse and adapted to be triggered thereby to initiate a wave signal, an amplifier connected to said second multivibrator for receiving and amplifying said wave signal, said amplifier being connected to said transducer and being adapted to transmit the amplified wave signal thereto, a circuit gate connected between the outlet sides of each of said multivibrators and said video receiver and a delay circuit connected between the outlet side of said second multivibrator and said circuit gate for preventing the premature triggering of said first-mentioned multivibrator upon receipt of an amplified wave signal from said amplifier, and means connected to said second multivibrator for measuring the repetitious rate of wave initiation by said second multivibrator as an indication of the length of the sonic path through said work member and the presence of defects or flaws in the walls thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,333,688 Shepard Nov. 9, 1943
2,458,288 Moriarty Jan. 4, 1949
2,756,404 Johnson et al. July 24, 1956

FOREIGN PATENTS

881,644 France Jan. 28, 1943